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BREAD AS A FOOD

CHANGES IN ITS VITAMINE CONTENT AND NUTRITIVE
VALUE WITH REFERENCE TO THE
OCCURRENCE OF PELLAGRA

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BREAD AS A FOOD.

CHANGES IN ITS VITAMINE CONTENT AND NUTRITIVE VALUE WITH REFERENCE TO THE OCCURRENCE OF PELLAGRA.

By CARL VOEGTLIN, Professor of Pharmacology, M. X. SULLIVAN, Biochemist, and C. N. MYERS, Technical Assistant, United States Public Health Service.

Bread has been from time immemorial the staple article of diet of the greater part of the human race. This statement applies particularly to people living under more or less poor economic circumstances, as the cereal foods are comparatively cheap and may be obtained easily at all seasons of the year. From the point of view of public health it is, therefore, of considerable importance that the bread supplied for human consumption should possess the highest possible nutritive value. The results of the investigations here reported refer particularly to conditions prevailing in the United States, and are the outcome of some studies on the causes of the occurrence of pellagra in this country. Apart from their bearing on the pellagra problem, they may be considered of interest from the viewpoint of human nutrition.

From the available data one may conclude that the nutritive value of bread made from corn or wheat remained much the same from the time of the early settlers until about 1880. During this long period bread was prepared from wheat flour or corn meal with salt and with or without the addition of other ingredients, such as fresh milk, buttermilk, molasses, etc. The wheat flour or corn meal was obtained by simply crushing the whole grain between stones, by various means, to the desired degree of fineness. The resulting flour or corn meal, from which the coarser particles of bran were partly sifted out, was then used for making bread. Accordingly the bread contained practically all of the nutritive elements of the whole grain. During the last 50 years, however, radical changes have taken place, with the tendency of reducing considerably the nutritive value of bread. The factors at work in this change are very closely connected with the radical changes in our social and economic life. It may suffice to call attention to two of the most important factors:

The rapid increase in the output of wheat and corn and the increase in the cost of labor necessitated the invention of mechanical devices for the more economic milling of these cereals. The introduction of the roller-mill system into the United States in 1878 represents probably the most important change in this direction. By

¹ Reprint from the Public Health Reports, vol. 31, No. 15, April 14, 1916, pp. 935-943.

means of the roller process it was made possible to separate the various parts of the kernel, namely: The germ or embryo, the bran, and the endosperm, or starchy part. The latter could then be ground to a very fine flour, which, on account of its white appearance, appealed to the housewife as an assumably purer product. The germ and bran were largely discarded as human foods and put on the market as food for cattle, horses, and swine. While it is quite true that the highly milled products (wheat flour, corn meal, corn flour, and grits) obtained by the roller process are far superior to the old-fashioned whole-wheat flour and corn meal so far as the keeping qualities are concerned, at the same time this modern process deprives the finished products of some valuable food constituents. A large number of analyses of such products made in the Bureau of Chemistry of the Department of Agriculture and at the Hygienic Laboratory clearly show that the highly milled wheat flour and corn meal contain less protein, fat, and ash than the old-fashioned products—a fact which would be expected, as the endosperm, from which the newer products are manufactured, is especially rich in starch cells.

Other things being equal, the lessened amount of protein, fat, and ash in the highly milled as compared with the undermilled products, while undesirable from the standpoint of nutrition, might be considered as a negligible change when compared with the better keeping qualities of the newer products, especially in view of the fact that in recent years it seems impossible to avoid long-continued storage of flour and corn products. The highly milled products, however, are often deficient in certain essential accessory food substances, which are designated as *vitamines*. These substances are located in the intact kernel in the outer layers (aleurone layer) and probably also in the germ. As seen above, the modern roller process eliminates to a great extent the bran and germ, and the resulting wheat flour, corn flour, and grits (hominy) might be expected to be deficient in *vitamines*, an assumption which has been amply verified by Myers and Voegtlin in work, the details of which will be published as a bulletin of the Hygienic Laboratory. It may suffice here to state that it was found that, whereas the corn meal and wheat flour made by the old-fashioned process, which is still in use to some extent in the South, contains practically all of the *vitamines* of the whole grain, the highly milled products are considerably deficient in these substances.

Fowl, the classical experimental animal for the physiological estimation of the *vitamine* content of foods, will live in perfect health for many months on an exclusive diet of wheat, corn, whole-wheat flour, or so-called "waterground" corn meal. If these animals are fed, however, on highly milled products they will die within a month or two of polyneuritis, a disease very similar to beriberi.

There seems to exist a perfect analogy between the well-known relation of the polishing of rice to its nutritive value, and the milling of wheat and corn to the nutritive value of wheat flour and corn meal. In the case of beriberi, numerous observations have demonstrated the fact that, if the diet of people is largely made up of highly polished rice and is otherwise deficient in vitamins, beriberi will make its appearance, whereas, if undermilled rice is substituted for the highly milled variety, the disease is not so likely to break out. Little¹ reports an outbreak of beriberi among the fishermen of Newfoundland, who lived mainly on bread made from highly milled wheat flour.

From these considerations it would appear that a simple method for the determination of the vitamin content of cereal products would be of great value. Unfortunately it is still impossible to base such a method on the direct isolation of these substances from the natural foods. The determination of the total phosphorus content of these products, however, seems to give a fairly accurate index of the relative amounts of vitamins present. While phosphorus does not enter into the vitamin molecule the distribution of phosphorus and vitamins within the grain runs practically parallel. Fraser and Stanton, on the basis of a large number of observations and analyses, came to the conclusion that rice containing less than 0.4 per cent of phosphorous pentoxide (P_2O_5) is deficient in vitamins. Myers and Voegtlin have used this method in order to correlate the vitamin content of wheat and corn products as found by animal experimentation with that of the quantitative estimation of the P_2O_5 content of these same products. Without going into detail, it was found that in the case of these cereals the same relation exists between P_2O_5 and vitamin content as in the case of rice. The following table illustrates this point:

	Per cent of P_2O_5 in dry food.	Number of days required for ap- pearance of polyneuritis in fowl fed exclusively on this food.
Wheat bread made from highly milled flour.....	0.114	20-32 days.
Whole wheat.....	1.120	No symptoms developed.
Corn grits (highly milled).....	0.169	23-50 days.
Corn grits (highly milled).....	0.210	30 days.
Corn meal (highly milled).....	0.30	35 days.
Corn meal (old-fashioned rock ground).....	0.659	Remained well.
Corn meal (rock ground).....	0.772	Remained well.
Corn germ.....	2.816	Remained well.
Corn, whole.....	0.760	Remained well.

While this method does not yield absolute values of the vitamin content of cereal products, we propose provisionally the following standard for wheat flour, corn meal, and grits (hominy): For corn products the minimum P_2O_5 content should not be below 0.50 per cent, that of wheat flour not lower than 1 per cent.

¹ Little. Jour. Am. Med. Asso. 1912. Vol. 58, 2029.

The method of determination of P_2O_5 is relatively simple. The products are dried at 100° C. and then ashed according to the Neumann method.

We believe that the determination of the P_2O_5 index will be found of value in all cereal products, except the so-called "Self-raising flours." These latter products contain baking powders, which often are composed of phosphates. As the label of these flours always indicates whether baking powder has been added, it would be an easy matter to discard such flours for this purpose.

We now should like to call attention to another factor involved in the reduction of the vitamine content of bread, especially corn bread. This concerns the use of baking soda in the preparation of bread. Simultaneously with the introduction of highly milled corn meal it was found that this product when mixed with salt and water did not yield a bread of the same lightness as the old-fashioned meal. Housekeepers, therefore, began to resort to artificial leavening. Baking soda (sodium bicarbonate) became very popular among them. This preparation is used very extensively for this purpose in South Carolina, where one of the writers (Voegtlin) had an opportunity of studying its uses in cooking. Bread made by means of baking soda has under certain conditions a distinctly alkaline taste and reaction. In order to prepare bread in this way corn meal is mixed with water or milk to which baking soda has been added. The resulting mush is baked in the oven. The high temperature in the oven liberates carbon dioxide (CO_2) from the baking soda (sodium bicarbonate) and the latter is transformed into sodium carbonate, a strong alkali. The evolution of CO_2 causes the bread to rise. Recent experiments by Sullivan and Voegtlin¹ have clearly demonstrated the destructive action of alkalis on vitamins.² These substances lose their physiological activity when exposed to alkalis, this being especially true at high temperature. Corn bread made from old-fashioned (whole) corn meal, sweet milk, and soda, when forming the exclusive diet of chickens, leads to symptoms of polyneuritis, whereas corn bread prepared from corn meal, sweet milk, and salt ($NaCl$) does not give rise to any symptoms, and fowls seem to live in perfect health.³ Chickens which have developed polyneuritis on the corn bread made with sweet milk and soda are cured by the administration of vitamins prepared from various foods. Hence, we may conclude that corn bread prepared by means of baking soda without the addition of buttermilk is deficient in certain essential accessory foods (vitamins) and that this deficiency

¹ Proc. Amer. Soc. Biol. Chem. 1916, xvi, p. 24, and unpublished data.

² Vedder & Williams, Philipp. Jour. Sci. (B), 1914, vol. 8, p. 175, and Fraser and Stanton, Lancet, 1915, vol. 1, p. 1021.

³ It should be stated that in a large series of experiments with corn bread made without the addition of soda one chicken, after several weeks, developed a temporary mild paralysis which was relieved by the administration of vitamins.

is due to the destructive action of the alkali (baking soda) on the vitamines which were originally contained in these foods.

The following table illustrates the destructive action of baking soda on the vitamine content of corn bread. Ten chickens were fed on corn bread of the following composition: 600 gm. of corn meal, 800 c. c. of sweet milk, and 10 gm. of baking soda.

Laboratory numbers of animals.	Number of days before appearance of polyneuritis after feeding was begun.	Laboratory numbers of animals.	Number of days before appearance of polyneuritis after feeding was begun.
31.....	13	37.....	19
32.....	14	38.....	21
33.....	27	39.....	13
34.....	13	40.....	16
35.....	22		
36.....	14	Average.....	17

Chickens fed on corn bread made with 600 gm. of corn meal, 800 c. c. of sweet milk, and 10 gm. sodium chloride did not subsequently exhibit at any time symptoms of polyneuritis.

It should be strongly emphasized, however, that the old-fashioned way of combining baking soda with sour milk in the preparation of bread is a perfectly harmless procedure provided that sufficient sour milk is added fully to neutralize the alkalinity of the baking soda. The label of the brand of baking soda most in use in this section of the South (Spartanburg County, S. C.) clearly states that sour milk or tartaric acid should be added in order to obtain the best results. The prevalent use in this section of the country of baking soda without sour milk or tartaric acid seems to be due to the ignorance on the part of the housewives as to the need of an acid, as well as to the fact that it is often very difficult to obtain sour milk.

The writers do not mean to imply that the use of baking soda without sour milk will always lead to an injurious action on the health of persons eating the bread prepared by this method, although such bread is undoubtedly deficient in vitamines. However, when the other dietary components, outside of corn bread, are also deficient in vitamines the consumption of corn bread made with baking soda without the use of sour milk accentuates this dietary deficiency and may lead to an impairment of health.

In conclusion the writers would like to consider very briefly the bearing of these findings on the occurrence of pellagra in the South. A number of investigators have suggested that pellagra belongs to the group of so-called deficiency diseases, meaning that the diet which gives rise to pellagra is deficient in certain accessory foods (vitamines) having no direct relation to the protein, fat, and carbohydrate content of the diet. This hypothesis is based on the observation that the

diet of people who develop pellagra seems to be made up of foods which are not rich in vitamins. In a general way the dietary studies in southern families made by the Experiment Station¹ of the Department of Agriculture, and some more detailed investigations by Voegtlin and Miss Nesbit (unpublished) seem to corroborate this observation. The last mentioned investigation is being carried out in Spartanburg County, S. C., in connection with the work of the Pellagra Field Hospital of the United States Public Health Service. The diet of the poorer classes of this section of the country contains large quantities of highly milled wheat flour, corn meal, fat pork, and fresh vegetables and is unquestionably poor in regard to its vitamin content. Pellagra has been endemic in Spartanburg County for at least seven or eight years. Previous to this time pellagra very probably occurred, but the disease was not so prevalent as at present. It is obvious that a satisfactory solution of the cause of this increase in pellagra incidence is intimately connected with the etiology of this disease. It is important that a satisfactory answer should be found as to how the dietary conditions of the population of the South changed previously to the great increase in pellagra.

We believe that this problem is quite complex, inasmuch as several factors must be taken into consideration. These are: (1) Changes in the economic conditions of the population; (2) changes in food production and food supply; (3) changes in the method of cooking food.

In regard to the influences of changes in the economic conditions of people on the composition of their diet it might be expected that a considerable decrease in the earning capacity of the poorer people, or an increase in the cost of foods, would be followed by changes in their diet. Everyday experience teaches that under such conditions the more expensive foods (meat, eggs, and milk) are reduced in the diet. People, as a whole, consume fewer eggs in the winter season when the supply of eggs is reduced and their cost correspondingly increased. Yet it seems that just these more expensive foods, such as milk, eggs, and meat, are efficient in the prevention and treatment of pellagra. These same foods are also rich in vitamins. A reduction of milk, eggs, and meat in the diet would, therefore, reduce its vitamin content, unless other dietary components rich in vitamins (legumes) were increased proportionately in the diet. An interesting example of the intimate relation between the appearance and disappearance of pellagra and changes in the economic conditions is found in the history of pellagra in France, referred to in a previous article.² Pellagra made its appearance in southwestern France (1820) soon after the reign of Napoleon, a period which was followed by extreme poverty. The available accounts characterize the diet of

¹ Bulletins No. 38, No. 71, and No. 221.

² Jour. Am. Med. Assn., 1914, LXIII, p. 1095.

the people at that time as extremely monotonous, being largely composed of cereals, fat pork, and a few fresh vegetables. With the improvement of the economic conditions beginning with 1860 pellagra began to disappear, simultaneously, it seems, with an improvement in the diet of the people, which now includes more meat, milk, and eggs. At the present time pellagra is practically unknown in France. A better illustration of the intimate relation between economic conditions, diet, and pellagra could hardly be found.

Sydenstricker,¹ in a recent statistical study, calls attention to the relation of pellagra to the rise in the cost of foods in the United States. He points out that as a result of the economic depression beginning with the year 1907 the cost of food has increased out of proportion to the increase in wages, and that the pellagra incidence has also increased considerably since 1907. Simultaneously there took place a reduction in the diet of the people of such animal foods as milk, eggs, and meat. We fully agree with this author that the above-described relations between pellagra and increase in the cost of food may explain, at least partly, the more or less rapid increase in pellagra during the last decade. The resulting reduction in the diet of foods relatively rich in vitamins (milk, eggs, and meat) might, therefore, have led to a dietary deficiency.

The writers believe, however, that other factors as above indicated may also play a rôle. It is interesting to note that beginning with the year 1878 the introduction of highly milled corn and wheat products began. These highly milled products began to replace the old-fashioned undermilled cereal products. This change took place gradually and is not completed at the present time, as there are still a good many old-fashioned mills in the South. On the whole the South, due largely to the increase of cotton farming and a decrease of the raising of corn and wheat became more and more dependent on the North for its supply of cornmeal, grits, and wheat flour. It was found that practically all of these cereal products consumed in cotton-mill villages in Spartanburg County and in Spartanburg city were highly milled products imported from Northern States or manufactured by southern mills using modern methods of milling. By means of the P_2O_5 index this was easily demonstrated. Feeding experiments of these products and others obtained from various sections of the South also showed them to be deficient in vitamins.

It should be emphasized, however, that the authors met with cases of pellagra in farmers who lived on old-fashioned corn meal, ground in old-fashioned mills from home raised corn. Very often these persons stated that they bought their wheat flour at stores which sold only highly milled imported products. It is impossible to get accurate statistics on the substitution of highly milled cereals for the under-

¹ Sydenstricker, Public Health Rep., 1915, Oct. 22.

milled products of former days, but from statements of wholesale dealers supplying this section of the country (Spartanburg County, S. C.), it would appear that during the last 15 or 20 years there has been a gradual increase in the highly milled products. This same period has also seen the great increase in the pellagra incidence.

Concerning the use of baking soda in the preparation of bread, it was found from inquiries made among housekeepers that the use of baking soda became very common some 20 years ago, simultaneously with the introduction of highly milled corn meal. It is difficult to ascertain how rapidly the use of baking soda in cooking was taken up by the people. The writers' experience in the cotton-mill villages of Spartanburg County has demonstrated that most of the families use this preparation at the present time, not only for baking bread, but even in the cooking of beans and other foods. This last-mentioned use of baking soda is the result of carelessness in cooking on the part of housewives in cotton-mill villages. Very often the person who attends to the cooking is also working in the mill, and has very little available time for the preparation of food for the family. Under these conditions the baking soda is added to beans and other foods in order to shorten the time of cooking, as the baking soda, when added to the water in which the beans are cooked, will cause the rapid softening of this food. There can be little doubt as to the greater or less destructive action of the soda on the vitamins of the beans under these conditions, although no direct experiments have been made on this point.

We see, therefore, that several factors seem to have played a rôle in the reduction of the vitamin content of the diet of the people of Spartanburg County during the last 20 years. Most prominent among these influences are: First, the reduction in the diet of vitamin-rich foods (fresh milk, eggs, and meats); second, the introduction of highly milled cereals; and, third, the use of baking soda, which was shown to have a destructive action on the vitamin content of bread. From the most careful and detailed investigation of the dietary conditions of certain communities in Spartanburg County it is evident that a large proportion of the people, especially in mill villages, live on a diet which is deficient from the point of view of its vitamin content. Wheat biscuits made from highly milled wheat flour and corn bread made with baking soda without the addition of buttermilk are the staple articles of diet among the people, and we have found families in which these foods represented about three-fourths of the entire diet. The fact that the above-mentioned influences, which have undoubtedly reduced the vitamin content of the diet, made themselves felt a relatively short time before the rapid increase in the pellagra incidence in this section of the country, fur-

nishes considerable evidence in favor of the vitamine-deficiency theory of pellagra. It will be left for future investigations to prove or disprove the correctness of this assumption for other pellagrous sections of the South. The reported results emphasize the fact that, in studying the etiology of any disease which is assumed to be of dietary origin, it is essential to pay careful attention to what might appear on superficial examination as trivial details.



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